Course Information Sheet

ECE516 Intelligent Image Processing

Steve Mann

Calendar Description
This course provides the student with the fundamental knowledge needed in the rapidly growing field of Personal Cybernetics, including "Wearable Computing", "Personal Technologies", "Human Computer Interaction (HCI)," "Mobile Multimedia," "Augmented Reality," "Mediated Reality," CyborgLogging," and the merging of communications devices such as portable telephones with computational and imaging devices. The focus is on fundamental aspects and new inventions for human-computer interaction. Topics to be covered include: mediated reality, Personal Safety Devices, lifelong personal video capture, the Eye Tap principle, collinearity criterion, comparametric equations, photoquantigraphic imaging, lightvector spaces, anti-homomorphic imaging, application of personal imaging to the visual arts, and algebraic projective geometry.

Course and course instructor
Multidisciplinary course with opportunities beyond the classroom:

Students participate in creating the frontier of Wearables, IoT, and AR, by co-authoring top-tier (IEEE, ACM) papers with Prof. Mann and developing new technologies to make the world a better place;

Former students of this course have gone on to start multimillion-dollar multinational companies like Interaxon and Meta;

A chance to join the world-class Humanistic Intelligence Lab where you’ll be surrounded by the world’s top electrical and mechanical engineers, physicists, mathematicians, and inventors;

Develop first-degree connections to the top thinkers, entrepreneurs, and investors at MIT, Stanford, Y-Combinator, and Rotman Creative Destruction Lab;

As the Chief Scientist of Rotman School of Business Creative Destruction Lab, where investors have a combined networth of over $2 billion, Prof. Mann can help students with enterprise and entrepreneurship-related efforts.

Learn how to do world-class research and publish papers in top-calibre IEEE conferences:

Design technology integrating with the human body, form, and function such as Digital Eye Glass Wearable Computing devices for AR (Augmediated Reality) Wearable Computing is not a $241 billion industry.

Thanks to Martine Rothblatt for funding "The Steven Mann Award for Wearable Computing", a cash prize awarded to the top undergraduate student in ECE516; last year’s recipient, Nima Yasrebi, received the $2500 cash prize.

A motto we live by is the IEEE’s motto "Advancing Technology for Humanity" (IEEE is the world’s largest technical society), and that was the topic of our IEEE ISTAS conference.

Course instructor
Steve Mann, PhD (MIT ’97), P.Eng. (Ontario).

Full Professor, University of Toronto Department of Electrical and Computer Engineering, with cross appointment to Computer Science, as well as to MIE (Mechanical and Industrial Engineering).
Chairman + CEO, Mannlab (http://mannlab.com).

Steve Mann, is widely regarded as "The Father of Wearable Computing" [IEEE ISSCC 2000]. His work as an artist, scientist, designer, and inventor made Toronto the world’s epicentre of wearable technologies back in the 1980s. In 1992 Mann took this invention from Toronto to Massachusetts Institute of Technology, founding the MIT Media Lab’s Wearable Computing project.
as its first member. In the words of the Lab’s founding Director, Nicholas Negroponte: "Steve Mann is the perfect example of someone... who persisted in his vision and ended up founding a new discipline."

Mann also invented the smartwatch videophone (wearable computer) in 1998, which was featured on the cover of Linux Journal in 2000, and presented at IEEE ISSCC2000, 2000 February 7, where he was named "The Father of Wearable Computing".

Some of Mann’s other inventions include HDR (High Dynamic Range) Imaging, now used in nearly every commercially manufactured camera, and the EyeTap Digital Eye Glass which predates the Google Glass by more than 30 years.

Mann has often been described as a modern-day Leonardo da Vinci:

“Steve Mann has been likened to artist, scientist, and inventor Leonardo da Vinci, .... He creates overlapping and inextricably intertwined syntheses of interventions and inventions that combine design, art, science, technology, engineering, and the environment.....”
– Ariel Garten, CEO, InteraXon

“In Professor Steve Mann – inventor, physicist, engineer, mathematician, scientist, designer, developer, project director, filmmaker, artist, instrumentalist, author, photographer, actor, activist – we see so much of the paradigmatic classical Greek philosopher. ... Steve has always been preoccupied by the application of his ideas into form. In this way too, he can be considered a modern day Leonardo Da Vinci.”
– K. Michael, Editor-in-Chief, IEEE Technology and Society

Steve received his PhD from MIT in 1997 and then returned to Toronto in 1998, creating the world’s first Mobile Apps Lab (1999) as a part of his wearable computing and AR course at University of Toronto, where he is a tenured full professor in the Department of Electrical and Computer Engineering with cross-appointments to Computer Science and MIE (Mechanical and Industrial Engineering, teaching the world’s first Inventrepreneurship (Invention + Entrepreneurship) course. Mann is a Visiting Full Professor at Stanford University Department of Electrical Engineering (Room 216, David Packard Building, 350 Serra Mall, Stanford, CA 94305), and is the Chair of the Silicon Valley Innovation & Entrepreneurship Forum (SVIEF).

He is also the Chief Scientist at the Creative Destruction Lab at Rotman’s School of Management. Mann holds multiple patents, and has founding or co-founded numerous companies including InteraXON, makers of Muse, "The Most Important Wearable of 2014", and Meta, a California-based startup, bringing wearable AR glasses to a mass market (built on Mann’s gesture-based wearable computing inventions [IEEE Computer, volume 30, number 2, pages 25-32, February 1997; USPTO 61/748,468, 61/916,773, and 20140184496]).

Mann is also the recipient of the 2015 Digital Pioneer Award.

1 Learning objectives for the course

ECE516 is aimed primarily at third and fourth year undergraduates, and first year graduate students. 4th year undergraduates often take this course as their "other technical elective" (fourth year elective). The classes are comprised of lectures and a lab/project (the lab has both a tutorial component and a grading component, etc.) starting in January, along with a final exam in April. The bulk of the grade is the project/lab, which the students work on throughout the entire term.

The course provides the student with the fundamental knowledge needed in the rapidly growing field of Humanistic Intelligence, also known as Human-in-the-Loop AI (Artificial Intelligence), as well as Personal Cybernetics ("minds and machines", e.g. mind-machine interfaces, etc.) and Personal Intelligent Image Processing. These topics are often referred to colloquially as “Wearable Computing”, “Personal Technologies”, “Mobile Multimedia”, etc..

The course focuses on the future of computing and what will become the most important aspects of truly personal computation and communication. Very quickly we are witnessing a merging
of communications devices (such as portable telephones) with computational devices (personal organizers, personal computers, etc.).

2 Content, on a week by week basis

- Week 1: Humanistic Intelligence for Intelligent Image Processing. Humanistic User Interfaces, e.g. Fluid User Interfaces, and other novel inputs that have the human being in the feedback loop of a computational process.
- Week 2: Personal Imaging; Metaphor-free computing, and Direct User Interfaces.
- Week 3: Intelligent Signal Processing, Machine Learning for Fluid-user-interfaces, etc.
- Week 4: EyeTap part 1; technology that causes the eye itself to function as if it were both a camera and display; collinearity criterion; Calibration of EyeTap systems; Laser EyeTap, computer vision, and Metasensing.
- Week 5: Eyetap part 2; Blurry information displays; Laser Eyetap; Vitrionics (electronics in glass); Vitrionic contact lenses.
- Week 6: Comparametric Equations part 1.
- Week 7: READING WEEK: NO LECTURE THIS WEEK
- Week 8: Comparametric Equations part 2: Quantum mechanics, and the link between quantum field theory and comparametric equations.
- Week 9: Comparametric Equations part 3: Comparametric Camera Response Functions.
- Week 11: VideoOrbits, part 1; background;
- Week 12: VideoOrbits, part 2; Reality Window Manager (RWM); Mediated Reality; Augmented Reality in industrial applications; Visual Filters; topics for further research (graduate studies and industrial opportunities).

3 Project assignment and schedule

Each student is expected to make weekly progress on their project, and to show that progress by actual live demonstration.

In this course, we use the MIT-method developed at MIT (Massachusetts Institute of Technology) and now practiced at Stanford, Berkeley, and Caltech. The MIT-method developed by Seymour Papert and Marvin Minsky, the father of AI (Artificial Intelligence), is best described by the following aphorism: “Demo or Die”. What that means is that ideas are demonstrated each week, and ideas that can’t be demonstrated effectively die out. Ideas that can be demonstrated effectively live. The ideas that live continue to be developed to the next week. There are no written reports. The marking is totally based on the “Demo or Die” presentations.

Presentations take place Friday mornings 9am to 12noon.

Rather than prepare rigid topics that are the same each year, the course adapts to current events, and most importantly, to student interests and passions. Thus each student has the opportunity to pursue an area of their own interest, in a deeply scientific and mathematically detailed way.

As a result, each of the students will often be working on different projects, that are, of course, all related to the general topic of the syllabus.
Rather than doing ten shallow labs each student or group did one very deep and profound 10-week lab.

Whereas many labs only come every-other-week, in this course, labs come EVERY WEEK. This is a solid rigorous course that has labs every week. The labs are the project milestones.

Students work on the project throughout each week, and the lectures strongly support the project.

In this way the labs are really a grading session for each incremental step of the project.

4 Laboratory content, and schedule

As mentioned above, the labs are the grading sessions of the project progress, and each lab is like a scrum of the project progress that week. Each student presents to the other students in a formal presentation at the front of the room.

In this way each student must prepare a detailed presentation each week, for presentation to the entire class every week. This ensures that there is regular progress every week.

Every week, students come and present their progress and receive constructive feedback on their projects. Students also effectively use this time to network and collaborate with other students in teams because most of the projects are multidisciplinary in nature.

**Real engineering focus:** In order to prepare students for the real world of engineering, we create a challenging environment that is based on the MIT model, and calibre.

Each student must present individual cutting-edge research at the MIT level, each week, to show that they are advancing along toward their project.

5 Textbook

The textbook was written by the course instructor S. Mann, and published by John Wiley and Sons, as part of the InterScience series.

5.1 Assessments and composition of marks for the course

- Closely supervised Work: 40% in class/lab working prototype demonstrations;
- Not closely supervised Work: 25% resulting in weekly project presentations in class/lab;
- Final exam: 35%. Exam is open book, open calculator, but closed network connection.

5.2 Course information sheets

The above includes Sections 1 to 5, and the document is the course information sheet.

**Photographic and videographic documentation**

Since there are no written reports in this course, we generally use presentations and demonstrations as the metric. Here are some “snapshots” of this process:

https://photos.app.goo.gl/xc90gdaQMkTVu2n1

This course has only 1 course project for the whole term (10 weeks of labs on 1 project) which uses the MIT method of teaching (demonstration-based, not written). Here are 9 examples (3 poor, 3 medium, 3 well):

http://wearcam.org/CEAB_ECE516_Project.pdf